Speaker:
Alexander Rodack

Application and Enhancement of the dOTF

2/13/2015

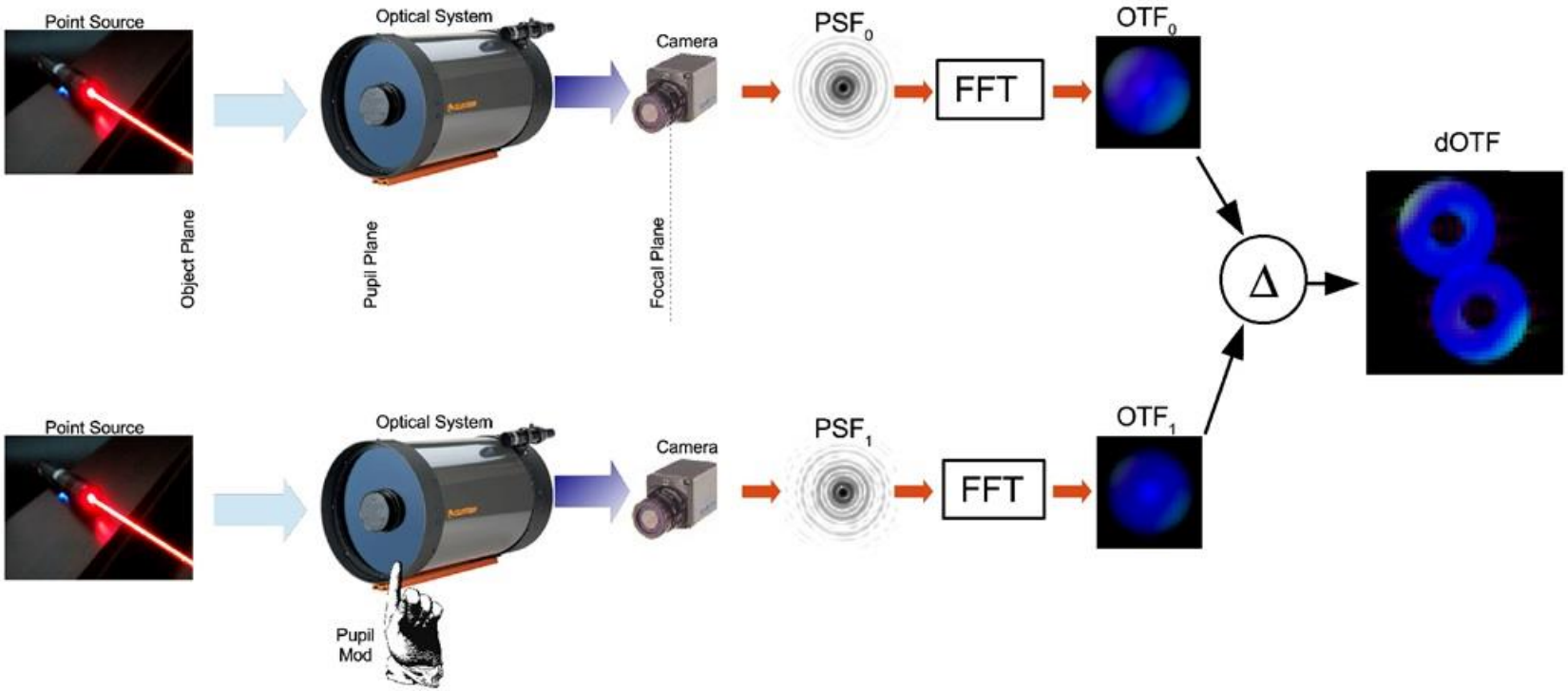
Outline

- A Brief Review of the dOTF
- Adaptive Optics Self-Calibration
- Using Deconvolution to Improve Results

The dOTF

The dOTF

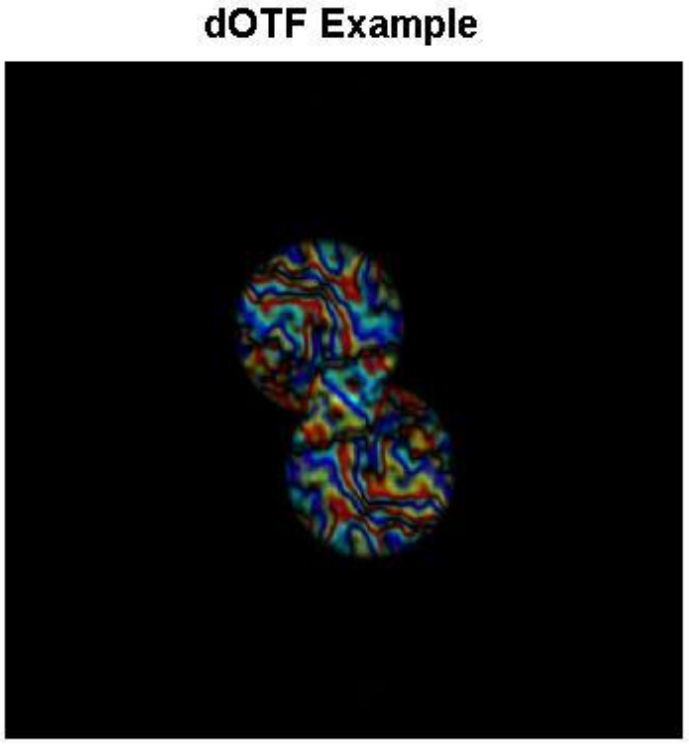
- Induced change in pupil mask – change in pupil field – change in OTF: 'differential' OTF



- J. L. Codona, "Differential optical transfer function wavefront sensing", Opt. Eng., **52**(9), 2013.

dOTF Wavefront Sensing

- The dOTF gives a measurement of the complex field in the pupil as seen by the Science Camera
- Wavefront sensor in non-photon limited systems
  - Calibration
  - Shop Testing



The dOTF examining the MMT Pupil with a Kolmogorov Phase Screen

Adaptive Optics Self-Calibration

Adaptive Optics Self - Calibration

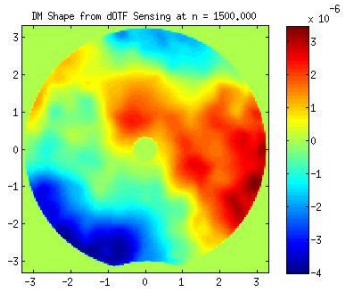
- PSF Self-Calibration
  - Closed-loop servo uses dOTF measurements to update DM actuation
  - “Flattens” DM
  - Corrects for non-common-path aberrations
- Intentional addition of defocus

Methods for AO Self-Calibration

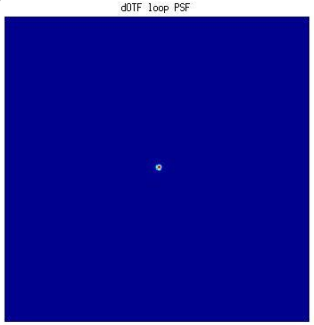
- Poke an edge actuator for a pupil modification
- Take 2 (or 3) pictures and compute the dOTF
- Mask off overlap region
- Read out displacements and slopes at segment/actuator positions directly from the phase measurements of the dOTF
- Replace directly measured phase with Reconstructor Matrix

Numerical Simulation Result

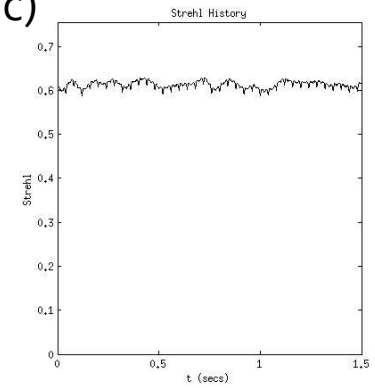
a)



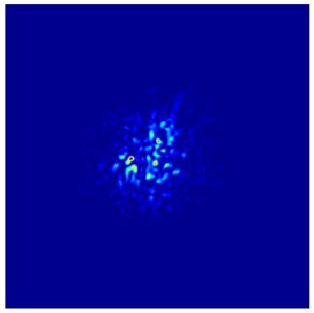
b)



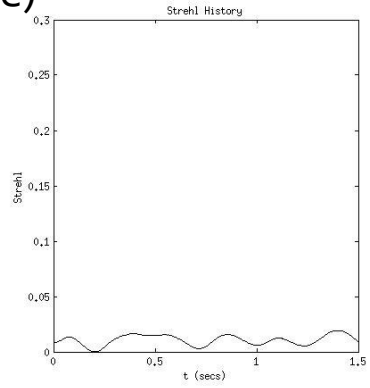
c)



d)



e)



a) DM Shape Calculated w/ dOTF
b) Corrected PSF
c) Strehl Ratio over time (corrected)
d) Uncorrected PSF
e) Strehl Ratio over time (uncorrected)

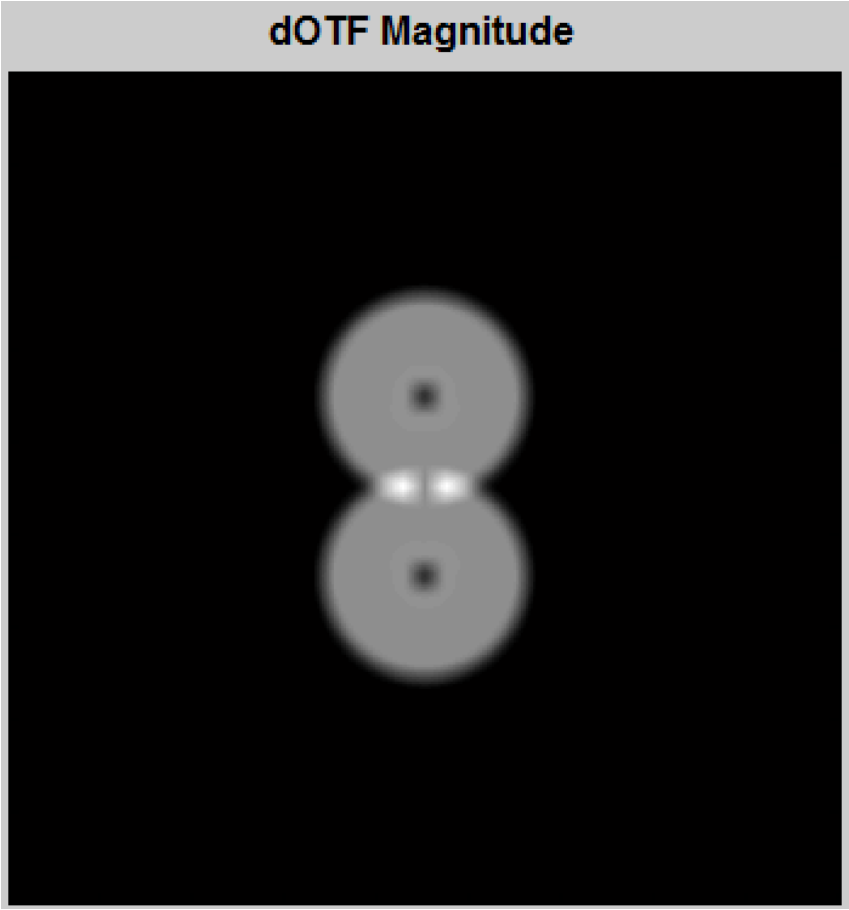
Using Deconvolution to Enhance the Loop

Deconvolution

- The dOTF field can be blurred:
  - Area – caused by the pupil modification
  - Radial – caused by the bandwidth
- We will focus on correcting the Area blurring
  - Algorithms in development for both

Area Deconvolution

- Method for Area Deconvolution:
  - Mask overlapping parts of the dOTF
  - Fourier Transform back into image space
  - Construct a Wiener filter to recover higher-resolution measurement

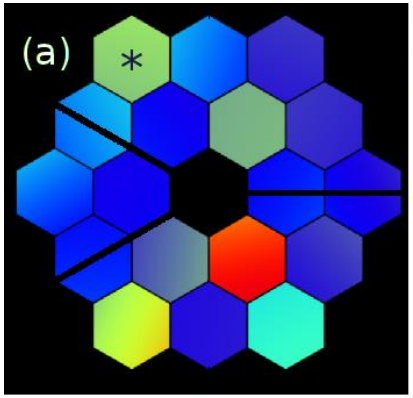


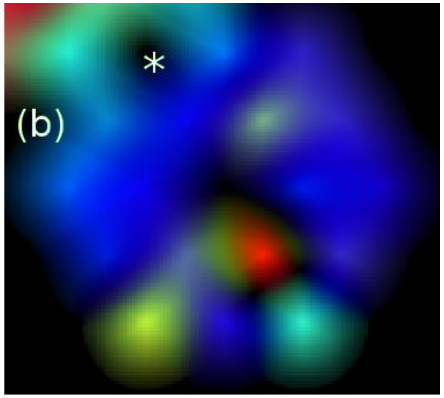
dOTF blurred by pupil blocker size

Initial Simulation

Simulation done using SVD to recover high-resolution information. Test 2 done with a higher number of modes included

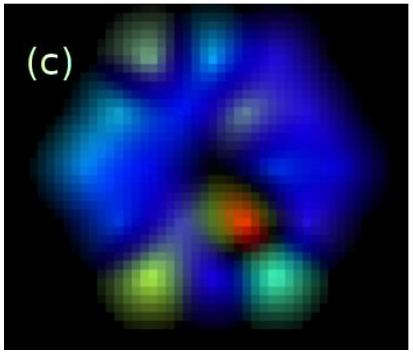
Simulated Complex Pupil Field

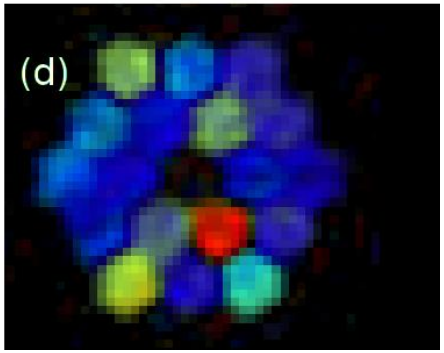




Optical Transfer Function (OTF)

Deconvolution Test 1





Deconvolution Test 2

Next Steps

- Verify self-calibration on the testbed
  - Different bandwidths
  - Varying amounts of collected photons
- Reconstructor Matrix

- Explore Deconvolution algorithms/techniques
- Apply Deconvolution to the Self-Calibration loop
  - Once this is done, further experiments can be done with a higher degree of accuracy